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ABSTRACT

A three-part experiment was designed to determine the differential effects of using audio, print, or a combined form, together with an inserted organizational and attentional aid (mathemagenic device), or lack thereof, in a syllable lesson on the test scores of six types of community college students: those who were internally or externally motivated, those who scored high or low on a pretest, and those who scored high or low on a reading comprehension measure. In order to obtain the data to test these hypotheses, six treatments were administered to 144 reading students. Each treatment included a combination of one mode and use or nonuse of a mathemagenic device with a two-part lesson on the concept of the syllable. Results indicated (1) mathemagenic devices still tended to be more helpful than not, with the exception of the audio/print treatment, especially for externally motivated students; (2) the print mode was best for high-reading-comprehension groups with or without mathemagenic devices; (3) the audio mode worked best with the mathemagenic device for internally motivated students and high-pretest groups and was especially successful for the low-reading-ability group; and (4) the use of the audio/print mode had the tendency to give the poorest results of all treatment groups using mathemagenic devices. (Author/HOD)

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THE RELATIONSHIP OF THREE STUDENT TRAITS, THREE MODES OF PRESENTATION, AND AN INSERTED MATHEMAGENIC DEVICE TO LEARNING FROM PROSE

Joan Rodriguez

Abstract

A three-part experiment was designed to determine the differential effects of using audio, print, or a combined form, together with an inserted organizational and attentional aid, or lack thereof, in a syllable lesson on the test scores of six types of subjects: students who are internally or externally motivated; those scoring high or low on a pretest; and those scoring high or low on a reading comprehension measure.

In order to obtain the data to test these hypotheses, six treatments were administered to 144 reading students. Each treatment included a combination of one mode and use or nonuse of a mathemagenic device with a two-part lesson on the concept of the syllable. The students were divided into six traits groups.

Because no three way interactions resulted all of the questions asked were answered in the negative. However, a two way interaction and several significant main-effect differences suggest that mathemagenic devices tend to be significantly helpful (in most cases), that an internal locus of control correlates with ability to do well on a reading post test and that careful consideration should be given to the mode by which good and poor readers are taught certain skills.

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Introduction

A number of educational researchers have obtained substantial support for the theory that students (i.e. readers of text materials) can benefit from extra-text reading aides. These devices apparantly help them to organize or attend to the main idea in the new information they encounter. Two of the most well known aides are the advance organizer and the post question.

Ausubel (1960 and 1968, Ausubel and Fitzgerald 1961, Ausubel and Fitzgerald 1962, Ausubel and Youssef 1963), investigated the merit of using advance organizers--general statements that briefly explain what will follow. He concluded that they serve three purposes. They encourage the reader to recall relevant information already stored in his memory. They make it more likely that the new information will be well-organized under an appropriately inclusive heading and therefore easier to retain and recall. Finally, they eliminate rote memorization to which students must resort when learning details in new subject matter because they have an insufficient number of "anchoring ideas." (Ausubel, 1968, p. 167)

Rothkopf (1966 and 1967) advocated the use of post questions which he inserted periodically throughout various reading selections. He attributed the success of this device to the fact that questions shape studying activities and that these behaviors "increase the liklihood of successful performance on the experimental question" (Rothkopf 1971,

p. 295) and, in turn, on the posttest question.

Given the feasibility of both these mathemagenic techniques, it seemed reasonable to hypothesize that taken together they would be particularly useful in ensuring a student's successf l understanding of a reading selection and his subsequent posttest performance. In other words it is possible that each of the types of instructional aides complement one another. The advance organizer provides a preview, a structure without which many students would find it difficult to organize and retain the content. The question, on the other hand, as well as conditioning him to look for important points as he reads, also provides a review in which the mind confirms the whole by attempting to extract a part. A "snowball" effect should then occur as an understanding of each section enables greater understanding of the next. An experiment was designed, therefore, to determine, among other things, if such a two-part device would improve a students score on a posttest based on a reading selection.

A review of the research indicates, however, that the extent of the effectiveness of such aides may be influenced by certain student traits, i.e. some students benefitted more from these devices than others.

Two traits about which some information is available in the literature in terms of their interaction potential with extra-text aides

include locus of control and general ability. Most of the data on the former trait involves the use of the question (Dowaliby 1974, Keller, 1975, Sturgis, 1975, Cronbach and Snow 1977). Although no significant interactions were uncovered, the results of several of the studies (Dowaliby, Sturgis and Cronbach and Snow) revealed that internals did better with the question condition or, as in Dowaliby's ($p < .06$), with the less direction question.

The most common criteria used to measure general ability, the second trait which may influence the effectiveness of a mathemagenic device (MD), was GPA. Among seventeen studies on the interaction of MD (either question or advance organizor) three found significant differences in favor of low verbal or low GPA using an MD while, with one exception, the remainder found either a trend in favor of the same condition and/or no interaction. (Apter, 1971; Ballard, 1965; Kuehls, 1972; Sanders, 1971; Smith, 1977; Cronbach and Snow, 1977; Dowaliby, 1974; Koran & Koran, 1975; Ausubel, 1968; Rickards, 1975-1976; Dapra, 1973)

Almost no research is available on preskill knowledge (i.e., knowledge measured by a pretest on the content of the lesson being presented) and the use of an MD. What is available (Sanders, 1973; Denzel, 1972; Cronbach and Snow, 1977 p. 358) indicates that preskill knowledge may interact with MD's. Some measure of particular student traits may be essential if one is also measuring some form of general

ability. That is, if one is interested in examining the relationship, if any, between the students need for an extra-text device and some measure of his ability to "handle" the text itself, one must be careful not to confuse reading ability (which correlates with GPA) with an adequate background in the specific subject being taught including a grasp of subject (lesson) related concepts and terms. For this reason task knowledge appears to be a trait worth considering in any investigation into the effectiveness of a mathemagenic device.

Finally, the manner in which the material is presented could also influence the effectiveness of the device. Although a question largely ignored in the literature, it seems likely that different types of mathemagenic behavor may be employed by the listener and the reader.

An experiment was designed then to look at the possible interactions between a two-part mathemagenic device used in conjunction with one of three different modes of presentation (print, audio, audio/print) and three potentially relevant student traits: reading comprehension level (as a measure of general ability), pretest scores and level of internal motivation (as measured by Rotter's I.E. scale).

This investigator decided to address the experiment to six questions concerning the potential interactive ability to the device. That is, when used in conjunction with various modes of presentation

(audio, print or audio/print) will the MD be of more use to individuals at one extreme of any of the three previously mentioned traits than to those individuals at the other extreme?

Question one asked whether externals, who appear to need outside prompting, would do best with as much stimuli as possible. It was hypothesized that they would prefer both audio and print input, together with a mathemagenic device. Question two asked of internals, who do not appear to be as annoyed by the presence of external stimuli as externals, would do better without a particularly directive structure, such as the MD.

Question one and two: Will externally motivated students (i.e., those who score in the upper half of the distribution on Rotter's I.E. scale) do better on a posttest when an MD is included in a print, audio or audio/print version of the material to be learned than when it is not? Will internals do better when MD is not included in the material to be learned than when it is?

Question three and four were based on the hypothesis that the most important differentiating factor among high-and-low pretest scorers would be the use of a mathemagenic device. Those who have little grounding in the subject matter would need organizational and review aids to help them grasp the content. Those who have some familarity with the subject would experience interference from these aides. This interference would cause the aids to act as a barrier to learning.

Questions three and four: Will low scorers on the pretest do better with an MD than without? Will high scorers do better without the MD? Question five asked whether or not those who scored at the lower end of a distribution of scores on a standardized reading test (SDRT) would need both audio and print channels to do well on the criterion measure--a test on the understanding and application of syllable rules. This investigator speculated that these low readers would also need a mathemagenic device to help them "chunk" ideas and phrases into meaningful units. Question six, however, implied that good readers would be hampered by an audio treatment since the medium through which they probably learn best is the printed page. They may also be distracted by the mathemagenic device which would interfere with their own "chunking" or structuring of sentences and concepts as they read.

Question five and six: Will the use of an MD be more helpful, especially in conjunction with the auditory/print mode than no MD for low scorers on a standardized reading measure? Will high scorers do better with the MD?

Method

The subjects were 144 students at a 6000-student-body community college located in a city with a population of 45,000. Data on the following aptitude variables were collected:

Locus of control. The Internal-External Scale (I.E. Scale), a 29-item multiple-choice measure, attempts to determine the extent to which an individual is able to reinforce his own behavior or the extent to which he relies on external reinforcement.

Pretask knowledge. A 20-item multiple-choice pretest on the syllable was designed to measure pretask knowledge. Two questions were taken from the material presented in approximately every three to five paragraphs of the text. The questions were concerned with either summary statements or important facts or were an application of one of the seven rules.

Reading comprehension. The Stanford Diagnostic Reading Test, Level II, Form A, Subtest 2, Reading Comprehension, was used to measure general reading ability.

One hundred and forty-five students who were attending various reading classes had been given subtest 2, Level 2, of the Stanford

Diagnostic Reading Test in the first week of class. They were then given the I.E. Scale and the Syllable Pretest. At that point the students were stratified on the locus-of-control variable with an equal number of highs and lows being randomly assigned to each of six treatment groups. During one of their regular reading class meetings, the subject received the first half of a lesson on dividing words into syllables. Depending upon their treatment groups, they were given either a cassette tape and/or text, with or without the insertion of mathemagenic devices--post questions and advance organizers. The second half of the lesson was given one week later during another class session. Each half took between 20 to 30 minutes to complete. A posttest was then administered to each student upon his completion of the second half of the lesson.

A 20-item alternate form of the pretest was used to measure the students' retention and understanding of, as well as their ability to apply, the information presented in the syllable lesson.

Subjects were exposed to one of six conditions in an effort to establish the existence of a pattern of interactions among the three student traits--locus of control, pretask knowledge, and reading comprehension--and the six conditions. The conditions involved modes of teaching with or without mathemagenic devices, as follows: (1) use of audio with no mathemagenic device, (2) use of print with no

mathemagenic device, (3) use of audio/print with no mathemagenic device, (4) use of audio with a mathemagenic device, (5) use of print with a mathemagenic device, and (6) use of audio/print with a mathemagenic device.

Condition one consisted of a taped lesson on the syllable, divided into approximately two equal parts. Each student was instructed to listen carefully to the program in its entirety.

In order to balance the amount of material listened to, or read, in both lessons, as well as the amount of time spent by the students on the lessons, the scripts without MD included some nonessential information at the end of part two. This information involved several paragraphs explaining the existence of a book which lists words divided into syllables, why the student should buy the book and where it could be purchased.

Conditions two and three were the same as the above except that the students received either a printed text to accompany the audio or used the printed text alone.

Under conditions four, five, and six, students received texts and/or tapes, as outlined above, except that, instead of a multi-paragraph discussion on the merits of a word guidebook, the script contained, first, an advance organizer and then a post-question after each three to five paragraphs. This two-part mathemagenic

device was physically isolated from the rest of the paragraphs by being placed on separate pages just after or before the relevant sections. Advance organizers were between one and three sentences in length and instructed the student, in general terms, as to what followed. The question asked the students to recall either a concept central to the preceding paragraphs or to apply knowledge gained from those paragraphs to a specific problem.

The procedure used to administer each of the treatments was repeated one week later when the second half of the syllable lesson was presented. Students were then given the syllable posttest to measure their recollection of and ability to transfer the information presented on the tape.

All three treatments took place simultaneously within each of the intact reading classes. Those students who used print alone were instructed to read their text carefully and, if there were questions, to attempt to answer those questions in their minds before proceeding, but not to look back for answers. Those who used audio received basically the same instruction in terms of how to attend to the lesson. Students in conditions two, three, five, and six each worked from a different tape and recorder.

For purposes of examining aptitude by treatment interactions, students were subdivided according to a median split, i.e., into a

high and low group for each aptitude score. The scoring below the 50th percentile were placed in the "low" group, and those at or above the 50th were included in the "high" group.

The first question of the study was tested with one 2 x 3 x 2 analysis of variance, i.e., use or nonuse of a mathemagenic device x modality type x high or low scores on the I.E. Scale. Locus of control and treatments were the independent variables, and the syllable posttest was the dependent variable.

For any significant F ratio obtained, contrasts between more than two means were examined using either Newman-Keuls for main effects or simple main effects of the interaction for significant interactions.

To ensure at least one unequivocal set of results, the sample was stratified according to locus of control. Providing that some high and low subjects fell into all 12 cells, hypotheses two and three were examined using two 2 x 3 x 2 analyses of variance, i.e., use of nonuse of a mathemagenic device x modality type x high and low scores on either variable measure. Unequal cell means were adjusted for using the harmonic n ($\tilde{n}$).

Results

The statistical analysis resulted in the following tentative answers to questions one through six.

Questions one and two:

Will externally motivated students (i.e., those who score in the upper half of the distribution on Rotter's I.E. scale) do better on a posttest when and MD is included in a print, audio or audio/print version of the material to be learned that when it is not? Will Internals do better when the MD is not included in the material to be learned that when it is?

Use of an MD did not differentially effect the performance of either externals or internals. A significant different was found for the locus main effect in favor or internals at the .05 level (see Table 1).

Although no significant interactions were observed, a glance at the graphic display depicting the cell means for each possible combination of variables (see Figure 1) suggests that the learning taking place may not be as straightforward as the main effect differences convey.

In these locus x mode x MD results, the mean posttest score of internals across all six conditions was higher than the mean of the externals at the .05 level; however, it is worth noting the direction of the line illustrating the superior performance, in mean score points,

Table 1

Analysis of Syllable Posttest Scores by Locus of Control, Mode, Mathemagenic Device

Source	df	Mean square	F
Main Effects			
Mode	2	3.813	0.598
Locus	1	40.955	6.423*
MD	1	15.211	2.386
2-Way Interactions			
Mode x Locus	2	4.766	0.747
Mode x MD	1	6.550	1.027
Locus x MD	1	7.126	1.118
3-Way Interactions			
Mode x Locus x MD	2	4.767	0.478

*$p < .05$.

by externals on the audio/print without mathemagenic-device treatment. Because externals consistently scored lower than internals on all other treatments, this occurence should be registered as a trend which may merit further investigation. (See Table 2). Also of interest is that the second widest gap between these sets of means occurs in the audio/print with mathemagenic-device treatment, this time in favor of internals.

Questions three and four: Will low scores on the SDRT pretest do better with an MD than without? Will high scores do better without the MD?

The ANOVA conducted for questions three and four was pretest x mode x MD. The results showed a significant difference in main efforts with pretest at the .01 level and in use of the mathemagenic device at the .05 level. Scores favored pretest highs and those who used a mathemagenic device. Nevertheless, the answer to both questions was no, due to lack of a significant three-way interaction (see Table 3).

An examination of means, however, suggests that the difference between mathemagenic and nonmathemagenic-device groups appear to be attributable to low pretest scorers. Their mean score difference with this treatment variable is 1.75 points. Indeed, for the high pretest group which used the audio/print mode, there is a mean score

Table 2

Set of Means for Locus of Control x Mode x Mathemagenic Device

Mode	With mathemagenic device		Without mathemagenic device	
	Internals	Externals	Internals	Externals
Print	14.31	12.31	13.63	11.90
Audio	14.43	13.42	12.93	11.91
Audio/Print	13.50	11.77	12.27	12.91

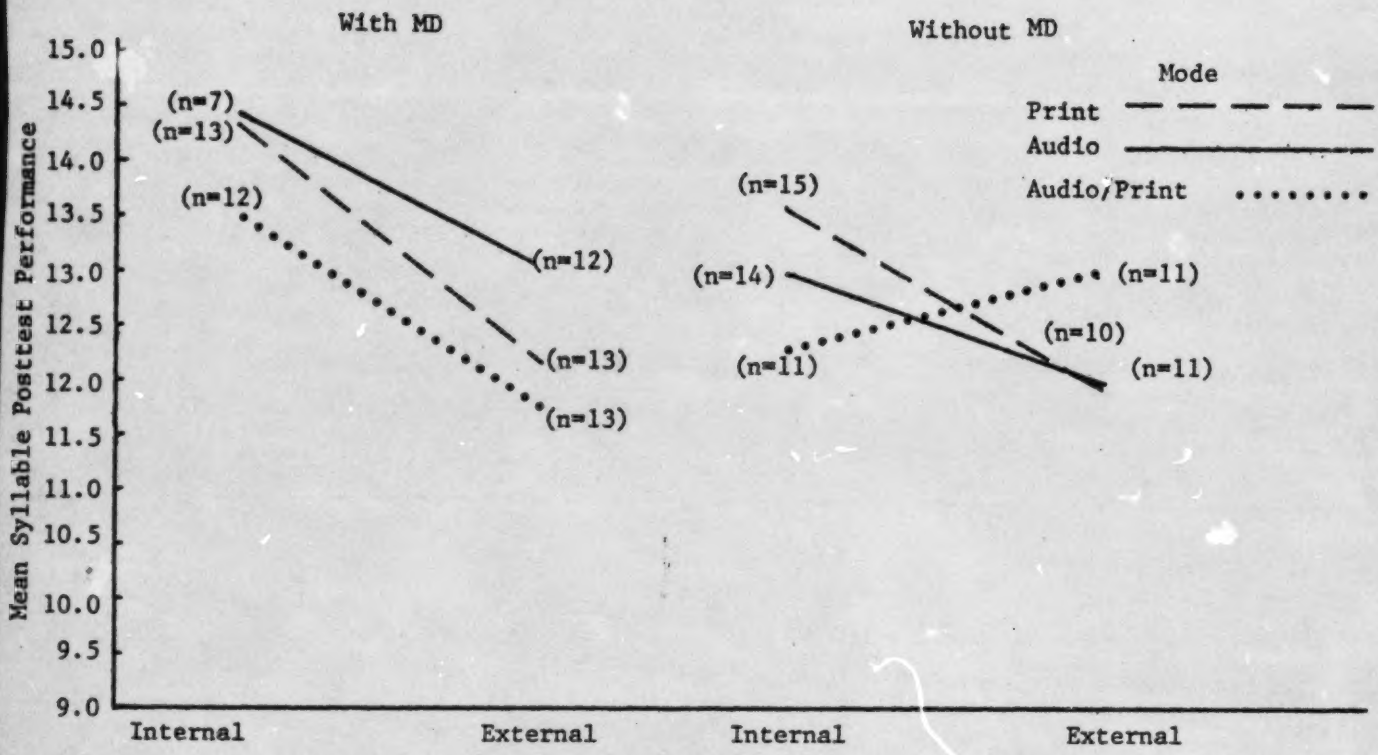

Figure 1. The set of means for Locus of Control x Mode x Mathemagenic Device.

Table 3

Analysis of Syllable Posttest Scores by Pretest, Mode, Mathemagenic Device

Source	df	Mean square	F
Main Effects			
Mode	2	9.091	1.793
Pretest	1	137.542	27.125**
MD	1	25.330	4.995*
2-Way Interactions			
Mode x Pretest	2	7.447	1.469
Mode x MD	2	5.962	1.176
Pretest x MD	1	7.113	1.403
3-Way Interactions			
Mode x Pretest x MD	2	8.085	1.594

*$p < .05$.

**$p < .01$.

Table 4

Set of Means for Pretest x Mode x Mathemagenic Device

Mode	With mathemagenic device		Without mathemagenic device	
	High pretest	Low pretest	High pretest	Low pretest
Print	14.77	12.20	13.83	9.33
Audio	14.91	12.25	13.19	11.42
Audio/Print	12.79	12.30	13.58	10.75

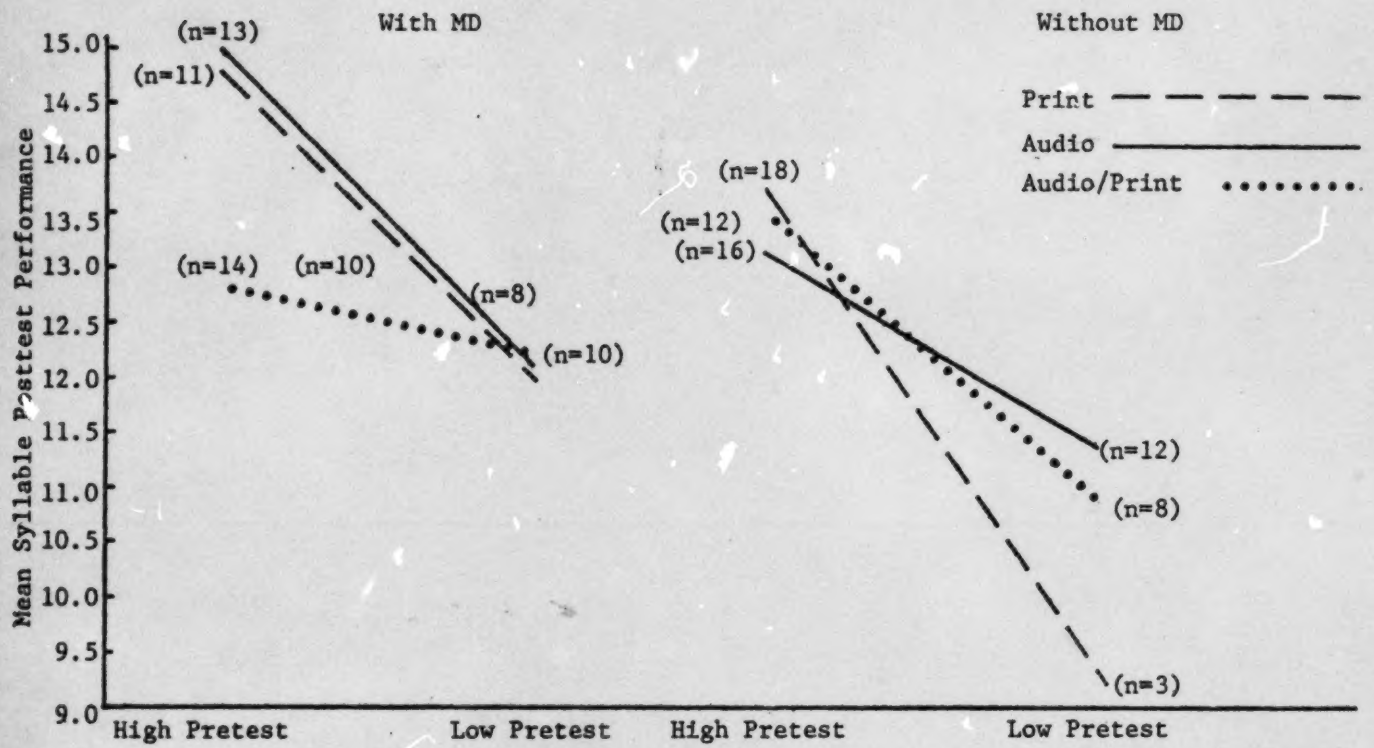

Figure 2. The set of means for Preknowledge x Mode x Mathemagenic Device.

difference in favor of those who used no mathemagenic device.

Question five and six: Will the use of an MD be more helpful, especially in conjunction with the auditory/print mode, than no MD for low scorers on a standardized reading measure? Will high scorers do better without the MD?

An analysis of results revealed three things: high SDRT scorers did significantly better than low ($p. < 01$); a post hoc test for simple main effects of the interaction revealed that the print treatment was responsible for the greatest difference between high and low Stanford Diagnostic Reading Test (SDRT) scores. (See Table 6) Figure 3 illustrates this point; finally, the use of an MD did not help or hinder either group to any significant extent.

A glance at Figure 4 suggests one additional comment on this last set of data. In the audio-with-mathemagenic-device treatment in which the lows scored the highest, they also outdid the highs' mean score in five out of six treatment groups.

Finally, an examination of Figure 3 and of the significance of F with regard to reading comprehension x MD ($p < .12$; see Table 5) may suggest that there is a potential interaction between these variables.

Table 5

Analysis of Syllable Posttest Scores by Reading Comprehension, Mode, Mathemagenic Device

Source	df	Mean square	F
Main Effects			
Mode	2	4.386	0.779
Comprehension	1	110.229	19.588**
MD	1	10.297	1.830
2-Way Interactions			
Mode x Comprehension	2	17.375	3.083*
Mode x MD	2	9.784	1.739
Comprehension x MD	1	14.580	2.591
3-Way Interactions			
Mode x Comprehension x MD	2	0.448	0.080

*$p < .05$. **$p < .01$.

Table 6

Set of Means for Reading Comprehension x Mode

	Reading comprehension	
Mode	High	Low
Print	14.00	10.60
Audio	13.48	12.17
Audio/Print	13.20	11.63

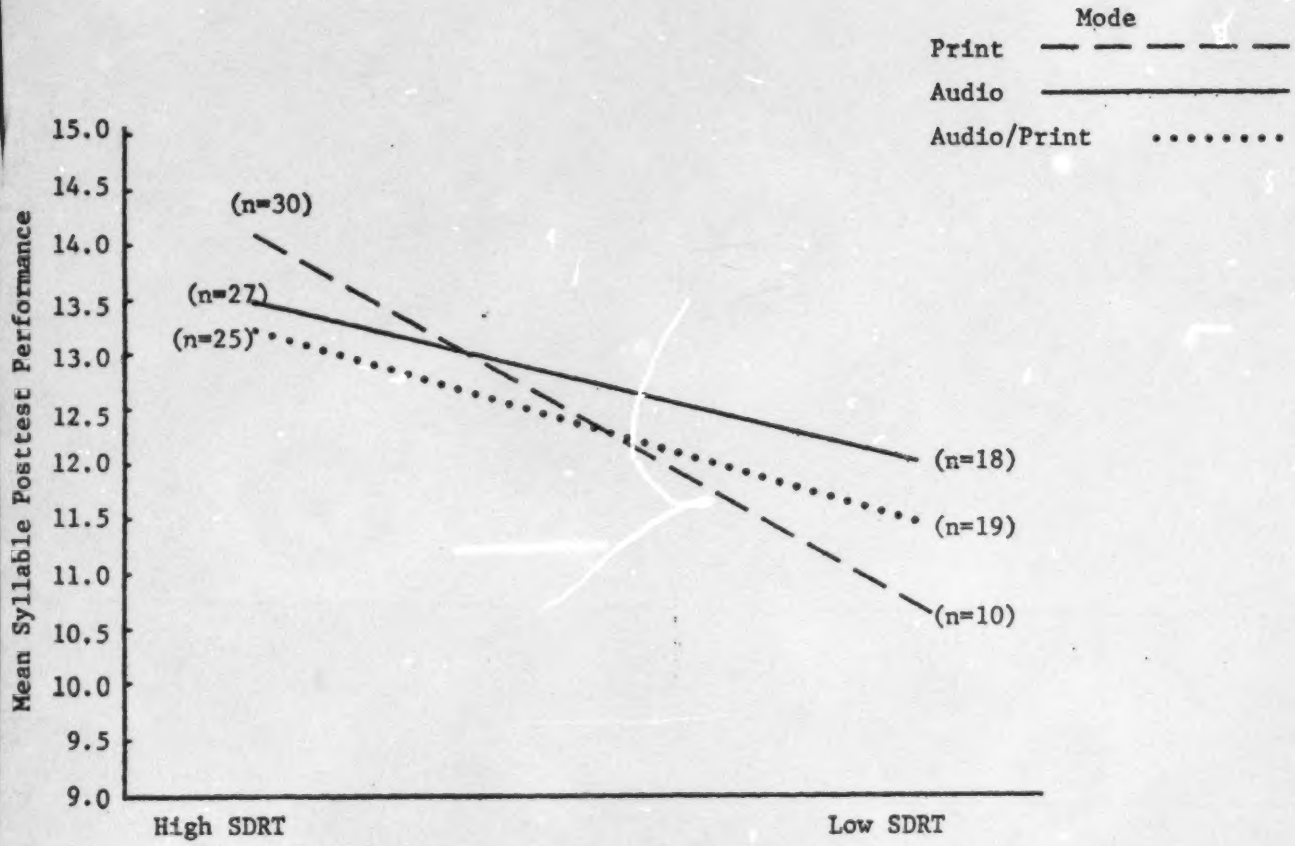

Figure 3. The set of means for Mode x Reading Comprehension.

Discussion

Although no significant two-or-three way interaction resulted in the attempt to answer questions one and two and although a significant main effect difference was found for locus, this investigator feels that further studies should be conducted regarding the possible interaction of certain treatments with the variable "locus." Even if, indeed, internals consistently score better than externals, certain treatments may still be more appropriate for one group than another. There is some evidence of this even in this study where the main effect difference was a result of the average of both groups' mean scores. One treatment, the audio/print-without-MD, however, appeared to result in scores which contradicted the average, meriting at least some speculation as to the cause of the contradiction.

One might suggest, for example, that the use of a series of organizers plus questions was helpful in a purely audio treatment, which produced the highest mean score for the externals. However the combination of audio and print created too much interference, even for externals. Perhaps this interference existed especially for the type of externals found in this experiment--externals with a tendency to be poor readers. Note that the audio/print treatment resulted in the lowest mean for internals when used with or without mathemagenic devices. Interestingly enough, the

audio/print treatment, when left to itself without MDs, did almost as much as externals as their highest score. This was a reversal, not only of the significantly superior performance by internals in this experiment, but also of the consistently helpful effects of mathemagenic devices revealed in all three ANOVAs. Needless to say this result may have occurred by chance but, it is worth a closer look to see if the use of extra-text reading aids interacts with some modes, helping externals and hindering internals in their efforts to learn and apply certain reading skills. This is suggested by Dowaliby's 1974 study.

The significant difference at the .05 level between high- and low-pretest scorers found while seeking the answer to questions three and four is not surprising. And, as with the difference found in the testing of the first hypothesis, it does not preclude the possibility that a particular treatment is better for one group than for another. Indeed, a glance at Figure 2 indicates that an interesting trend may be occuring with the means of the low-pretest scorers who used mathemagenic devices. It echoes, to a limited extent, the results found by Ausubel and Fitzgerald in 1962. Although there is a significant main effect difference between MD and no-MD ($p < .05$), a closer examination of the data reveals that the difference lies more with the low-

pretest groups. And, indeed, the high-pretest group which used the audio/print treatment scored lower with the MD than without. At least the direction of the means, then, supports one of the premises behind question three. Those learners who are less knowledgeable in a subject matter may be more in need of preview- and review-like statements to help them organize and internalize new material and, in turn, to apply the knowledge gained.

The two-way interaction at the .05 level obtained in the third ANOVA (performed for questions five and six) is certainly the most substantial evidence of interplay between any of the variables being investigated here. The set of means (see Figure 1) indicated that two rather interesting things were occurring. Whereas high-SDRT scorers were performing very well, in relative terms, with the print alone on a skill which involves considerable auditory associations, the low SDRTs did particularly poorly with the same modality. On the other hand, the same group was able to recall oral descriptions of letter combinations-without syllable-letter-sound patterns better when having no print input at all. This was reflected on a test using print alone. This result is contrary to the hypothesis behind question five which asserted that even poor readers would need the combined input of print and audio to aid them in an area that by its nature involved recalling both printed and auditory elements. This seems to

support one other investigation which discussed low-and-average-intelligence students' preference for audio tapes (Remy, 1976). These results may suggest that more purely audio material should be utilized to teach low readers some fundamental rules in decoding and comprehension. Better readers, on the other hand, may do best if taught a skill, such as vocabulary, with print as the primary vehicle.

Another significant difference found in this set of data was, unsurprisingly, a difference in favor of high SDRTs over lows. Better readers will probably always have an advantage over lows in learning a reading-related lesson. However, in both audio and print treatments, both high and low groups which used an MD obtained higher mean score points than those which did not use the device. This suggests that further investigation might uncover a two-way interaction between either or both of these modes and the use of a mathemagenic device.

The results will now be examined in terms of what information they provide with regards to mathemagenic device and mode.

Mathemagenic device. Things have not changed since Ausubel and Rothkopf's research. Mathemagenic devices still tend to be more helpful than not. (See significance of *F* ratios for MD in Tables 1, 3, and 5.) The exception appears to be the audio/print

treatment, especially for externals. Could it be that the poor readers, a majority of the population in this experiment want the help of an MD, whereas the externally motivated individual finds it difficult to ignore the printed stimuli and therefore becomes more confused? Overall, however, we should perhaps have taken more seriously the results of experiments by Ausubel and Rothkopf in this area, i.e. more learning materials should include their kinds of textual aids.

Print mode. The significant two-way interaction combined with the direction of mean scores indicates that this treatment was best for high-reading-comprehension groups with or without mathemagenic devices. There was a slight tendency for this mode to be better for high-and-low-pretest and internal-locus groups without MD. Audio was slightly better than MD for these groups. The first finding above is self-explanatory. The second may suggest the question, "What interaction, if any, exists between the mathemagenic device and audio treatment for these groups?" It is possible that, for the generally poor reader, a printed MD is simply more of what is already a difficult medium to process and that the concept of providing anchoring ideas in the appropriate medium is sound but, otherwise, an added burden. Gagne' (1970), for one, points to the need for teachers to begin

instruction at a point of familiarity for students and specifically refers to utilizing the most appropriate medium.

Audio mode. According to simple means, this mode appeared to be somewhat more successful than this investigator had anticipated. It worked best with the mathemagenic device for internals and high-pretest groups and was especially successful for the low-reading-ability group.

Audio/print mode. The use of two channels had the tendency to give the poorest results of all treatment groups using MDs. Without MD, it fared slightly better. Three out of six times it came in second. Twice--for externals and low SDRTs--it came in first. Even these mean scores, however, remain lower than audio with MD for the same groups. If we look at these means, together with two of the studies reported in the review of the literature (Dowaliby, 1974; Hord, 1976), we might very tentatively suggest that too much external stimuli act as overload on some students' mental processing. At a glance it would seem to support Broadbent's 1958 theory, cited in Levie and Dickie (1973), that an individual is only able to attend to one piece of information at a time. However, the fact that the two groups mentioned above were able to do almost as well, in terms of cell means, with both modalities as with each separately may indicate that a bimodal

treatment has some interaction potential. In other words, whether Broadbent's theory is true may depend upon the traits possessed by the learner.

Although none of the questions could be answered in the positive because of the lack of three-way interaction, the direction of some of the treatment group means suggests that further investigation of the relationship between some of these variables is warranted. This investigator would be in favor of mini-experiments which looked at one of two issues at a time. All future experiments should use larger samples with a wider range of reading ability and, in this way be able to block on the first and last thirds of the variable measure's distribution. In the opinion of Cronbach and Snow (1977, p. 60), "a design treating upper and lower thirds of the population, or upper and lower quarters, is appreciably more powerful than a study with the same N distributed over the full aptitude range." And, for observing interactions, "an investigation with a small sample is likely to accept the null hypothesis as tenable even though a powerful effect is present" (Cronbach & Snow, 1977, p. 80).

Also, a pilot group, drawn from the intended population, should probably be used to determine whether or not the dependent variable was especially difficult for that population. If this

proved to be the case, questions could be altered until some acceptable level of difficulty was attained.

Some specific questions which might be addressed include:

Does an interaction exist between use of an MD and the audio and print modes with both high and low-reading-ability students? Is the print mode particularly useful for high-reading-ability students, while harmful for lows? Is there a high correlation between locus and reading ability? Do low-preknowledge subjects find the use of MDs more helpful than no MDs, if either audio or audio/print modes are used?

Some current research in the area of cognitive processing is involved in analyzing the phenomenon of "chunking"; that is the uncovering of the relationships among specific pieces of information before that information can be internalized. For this reason it is most important that we carefully examine the role of the mathemagenic device. Not only may it help design educational treatments, but perhaps more importantly, it may also provide valuable information on how certain students structure as they read and why (or if) some students are unable to.

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